

STOCHASTIC SCANNING DOCUMENTS TO CHANGE MOIRÉ EFFECTS

Related Applications:

This applications is a continuation of application 09/099,864 filed 6/18/01.

Field of the Invention:

The present invention relates to document scanning and more particularly to a method and apparatus for changing the Moiré effects introduced by conventional scanning apparatus.

Background of the Invention:

Existing document scanners can generally be classified as either flatbed scanners or drum scanners. Flatbed scanners generally have a linear array of detecting devices such as linear charge coupled devices (CCDs). The space between the detecting devices determines the horizontal resolution of the scanning device. The speed that the array is moved along the document and the rate at which the devices are read, determines the vertical resolution of the scanning device. Flatbed scanning devices which have 300 to 600 CCD elements per inch are commercially available.

Drum scanners generally have a single photo-detector and a scanning beam of light. The beam of light scans across a line of the document as the document moves around the drum. The light reflected from the document is directed to the single photodetector. The horizontal resolution of the scanner is primarily determined by the frequency that the output of the single photoreceptor is sampled as the light beam moves across a line of the document.

Drum scanners can also include a linear array of detectors and there are many other types of scanners which combine elements from the above described two general types of scanners.

Scanning a document at a particular resolution (for example at 600 pixels per inch) can introduce patterns into the data. The patterns introduced into data by scanning appear when the scanned data is printed or displayed. Such patterns are frequently referred to as Moiré patterns.

In some instances special patterns are intentionally introduced into an image so that when the image is scanned and then reproduced the Moiré patterns produce visible images. When such images are visible it indicates that a document is not an original, that is, the image was created by scanning an original. Such technology is well developed and is for example described in issued US Patent 5,735,547.

The present invention is directed to a method and apparatus for scanning a document in a manner which changes how and whether Moiré patterns are introduced into an image when the image is scanned.

Summary of the Invention:

With the present invention an additional motion is introduced into the scanning operation. This additional motion introduced by the present invention is in addition to the motion that is inherent in any document scanning operation. For example, in a flatbed scanner a linear array of scanning devices is positioned across the document in

a first or "x" direction and this array is moved across the document in a perpendicular or "y" direction. In a flatbed scanner the position of the scanning devices are fixed in the "x" direction. In a drum scanner a light beam moves across the document in an "x" direction and the document is moved in the "y" direction. The light reflected from the document is directed to a fixed photoreceptor. With the present invention an additional vibratory motion is introduced into the scanning process. With a flatbed scanner the array of detector devices is moved or vibrated. The vibratory motion can for example be in the "x" direction. With a drum scanner the photoreceptor is moved or vibrated. For example the photodetector can be moved or vibrated in the "x" direction. The amount and direction of the vibratory movement can vary up to about one half the distance between units in the scanner's resolution (i.e. one half a pixel). If one is trying to eliminate Moiré patterns the vibratory movement can be a pseudo random series of movements. If one is trying to introduce a special pattern into the document or to otherwise create special effects, various other type of motion can be used. Movement of the CCD array in a flatbed scanner or movement of the photoreceptor in a drum scanner can be done by a simple piezo electric transducer or by a simple mechanical cam.

With the present invention, the data generated by the vibrated scanning device can be manipulated to generate a digital image similar to that which would be generated by a normal scanning element, except that the digital image so generated does not contain the majority of the Moiré patterns that would have been generated by a normal scanning element. The data from the vibrated scanning element can also be manipulated to enhance certain desired effects. That is, the present invention can be used to enhance patterns that are intentionally placed in an image. For example, an image can be

constructed so that it will contain a pattern that will only be visible if the image is scanned with a scanner which is operating in accordance with the present invention.

Brief Description of the Drawings:

Figure 1 is an overall diagram of a scanning system which utilizes the present invention.

Figures 2A and 2B are diagrams showing how the CCD scanning array and the piezo electric transducer are mounted on the frame.

Figure 3 shows the scanning array in a series of different positions.

Figure 3A illustrates the pattern of pixels created by a scanner which does not utilize the present invention.

Figure 4 shows the location on a document of the pixels from the scanning element..

Figure 5 shows how the data from the scanner is combined.

Figure 6 shows a preferred embodiment of the invention.

Detailed Description:

An overall diagram illustrating the present invention applied to a flatbed scanner is shown in Figure 1. The scanner shown in Figure 1 has a scanner bed 10 on which is position a document 11. A moveable scanning carriage 12 contains a light source 13 and a linear array of charge coupled devices (CCDs) 14. A line on the document 11 is illuminated by LED light source 13. An image of the illuminated line is focused on CCD detector array 14 by a lens (not explicitly shown). The array 14 is moved across the document in the y direction (by a conventional mechanical mechanism which is not explicitly shown in the drawing). A microprocessor 20 controls the operation of the entire system and signals from the CCD array 14 are stored in memory 20A. As the system scans a document 11 the signals from array 14 creates a digital image of the

document in micro-processor memory 20A. All of the above elements are conventional and they are found in many commercially available flatbed scanners. The present invention involves transducer 15 which is positioned at the end of array 14 and which will be described later with reference to Figures 2A and 2B.

Figure 3A illustrates the image of document 10 which would be created in memory 20A if the system operated in a conventional manner without the present invention. The image has pixels 10a, 10b, 10c, etc. arranged in uniform rows and columns. The memory 20A stores a number for each pixel which indicates the intensity of that pixel. For completeness it is noted that a color scanner would store three numbers for each pixel to indicate the intensity of each of the three primary colors in each pixel. The preferred embodiment of the invention will be described as a single color (i.e. a black and white) scanner. However, the invention can be extended to a color scanner by handling each color in the same manner that a single color is handled in the embodiment described herein.

The speed at which the array 14 is moved in the "y" direction and the rate at which the CCD devices 14 are read must be coordinated. For example in a scanner which is designed to create an image with 600 pixels per inch, if the time required for the array 14 to move 1/600th of an inch is one millisecond, a reading must be taken from the CCD elements in array 14 each millisecond. That is, the rate at which data is read from CCD devices in array 14 must be coordinated with the speed that the array 14 is moved in the "y" direction so that a new row of pixels is in position to be read each time the CCD elements in array 14 are read.

an expanded view and thus all of the elements in array 14 can not be shown on the figure. It should also be noted that the movement of the array 14 in the "y" direction along the document is in fact continuous and the positions discussed here are the positions of the array at the specific times that the CCD devices are sampled or read. At time T1, the scanning array 14 is in what will be called the "home" position. After the value is read from the CCD devices in the home position, the array 14 moves one pixel position in the "y" direction and the array 14 is moved one half a pixel position in the "x" direction 28. A second set of values is then read from the CCD devices 25. Next the array moves one more pixel position in the "y" direction and the array 14 is moved one half a pixel position back to the home position. The process is then repeated.

Figure 4 shows the document 11 with an indication of the location of the pixels that are read by CCD elements 14a, 14b, 14c, etc. It is noted that the edge portions of the document are ignored and only the information in the area designated by line 41 is of interest. It is also noted that since the document is shown enlarged in Figure 4, only the top left corner of the document is shown.

The pixels in each row of the document are designated as by two numbers. The first number indicates the row where the pixel is located and the second number indicates the position of the pixel in the row. Thus the third pixel in the second row is designated as "2,3".

Figure 5 illustrates the data in memory 17 which represents the data from area 41 of document 11. Figure 5 represents an array of numbers stored in a memory in a conventional manner to represent an image. The images are arranged in rows and

columns. Two letters are used to represent each number. For example "B,C" represents the third number in the second row. The number "B,C" is a number stored in memory 20A which represents the value of a particular pixel in the image.

The values represented in Figure 5 are calculated from the values read from the CCD devices as they scan each of the pixels shown in Figure 4. The values in the first row are the direct values read from the scanning elements. For example value "A,B" is the value read from a CCD element as it scans pixel "1,3" shown in Figure 4. The values in row B are calculated values. For example value "B,A" is derived from the values read from the CCD elements as they scan pixels "2,1" and "2,2". The value of "B,A" is one half the value of "2,1" plus one half the value of "2,2". The reason for this is that the value "B,A" represents a pseudo pixel that is located half way between pixels "2,1" and "2,2". Each of the other values for the values in rows 2, 4, 6, etc. are calculated in like fashion.

From a physical point of view, a first set of values is read when the scanning array 14 is in position shown in T1 in Figure 3. Next the array 14 is moved in the "y" direction by an amount equal to one pixel position and the scanning array 14 is moved one half a pixel position in the "x" direction 28 and a second set of values are read from the scanning array 14. The process then continues as previous explained. If the values read as described above were directly printed, on a conventional printer, the image would be distorted, since a printer prints the value of the pixels in the second row of an image directly beneath and aligned with the pixels in the first row of an image.

The above distortion which would occur due to the fact that the scanning array is moved between rows of pixels in an image is what necessitates the calculation of "pseudo" pixels as previously described.

In the simplified embodiment of the invention described above, the calculation of the value of the pseudo pixels is relatively easy since the scanning element is moved a uniform one half pixel amount between each scan row. In the preferred embodiment of the invention shown in Figure 6 and described below, the calculation becomes somewhat more complicated.

In the preferred embodiment of the invention shown in Figure 6, the scanning element 25 is moved in accordance with a pseudo random pattern. As shown in Figure 6, the pseudo random pattern has fifteen different values between 10 and 90 percent. Each value represents the percent of the width of a pixel which the scanning element is moved during a particular time period. For example the scanner might be moved by the following amounts over fifteen rows of pixels:

T1	.27% of a pixel
T2	.12% of a pixel
T3	.60% of a pixel
T4	.19% of a pixel
T5	.15% of a pixel
T6	.19% of a pixel
T7	.22% of a pixel
T8	.59% of a pixel
T9	.00% of a pixel
T10	.62% of a pixel
T11	.25% of a pixel
T12	.02% of a pixel
T13	.39% of a pixel
T14	.75% of a pixel
T15	.78% of a pixel

The above series of numbers is merely intended as an example. The mathematics for generating a series of pseudo random numbers is well developed. While in general the above numbers will provide satisfactory results, in various applications other series with more or less numbers and series generated with other random number generators may be better. The particular numbers used is a matter of choice for each particular application.

A system which utilizes a series of random numbers to determine the amount of movement between rows of pixels is shown in Figure 6. The CCD scanner 25 and the driver 26 are similar to the previous embodiment. The series of numbers which specify the amount of movement are stored in memory 63. A driver control 27 reads the numbers from memory 63 and sequentially activates the driver 26 with signals which have a magnitude controlled by the numbers in storage 63. The output of the scanner goes to memory 61. The calculating device 65 combines the values from memory 61 into a final image based upon the amount of movement of each line.

In the previous example where the scanning element was moved one half of a pixel, the numbers in the final image was calculated by taking one half of the value of two pixels. In the situation described in the present embodiment the calculation is somewhat more complicated. For example if the movement is .25 of a pixel, the final value of a pixel would be calculated by taking .25% of the value of one value and .75% of another value.

The diagram shown in Figure 6 shows a number of discrete components. it should be recognized that the components shown in Figure 6, could be discrete components;

060606

As a simplified example consider an image which is printed at 1000 pixels per inch and which is scanned at 750 pixels per inch. Consider that the pixels in the image are printed in the pattern given below. In the following lines the numbers “9” and “6” indicate the intensity of a pixel. The underlining is only added to emphasize the pattern of the pixels.

699669966996699669966996699669966996699669966996

699669966996699669966996699669966996699669966996

699669966996699669966996699669966996699669966996

With a conventional scanner, each scanned pixels would cover three of the original pixels and have one of the following values (where the numbers "24" and "21" indicate the values of the scanned pixels. The underlining shows the pixels in the original that are grouped together in the scanned pixels.:

699669966996699669966996699669966996699669966996

24 21 21 24 24 21 21

699669966996699669966996699669966996699669966996

24 24 21 21 24 24

699669966996699669966996699669966996699669966996

21 24 24 21 21

The above shows each scanned lines. With a conventional scanner the lines which appear beneath each other would be as follows for each of the above examples:

24 21 21 24 24 21 21
24 21 21 24 24 21 21
24 21 21 24 24 21 21
24 21 21 24 24 21 21

or

24 24 21 21 24 24
24 24 21 21 24 24
24 24 21 21 24 24
24 24 21 21 24 24

or

21 24 24 21 21

CITIZENS

24 21 21 24 24 21 21
24 24 21 21 24 24 21 21
24 21 21 24 24 21 21
24 24 21 21 24 24 21 21

24	24	21	21	24	24	
21	24	24	21	21	24	24
24	24	21	21	24	24	
21	24	24	21	21	24	24

21	24	24	21	21	
21	21	24	24	21	21
21	24	24	21	21	
21	21	24	24	21	21

It is noted that the above is a very simple example to illustrate the principle involved.

The same technique could be used with the preferred embodiment of the invention where the scanner is shifted in a more complicated pattern.

[illegible][illegible][illegible]

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	2101	2102	2103	2104	2105	2106	2107	2108	2109	2110	2111	2112	2113	2114	2115	2116	2117	2118	2119	2120	2121	2122	2123	2124	2125	2126	2127	2128	2129	2130	2131	2132	2133	2134	2135	2136	2137	2138	2139	2140	2141	2142	2143	2144	2145	2146	2147	2148	2149	2150	2151	2152	2153	2154	2155	2156	2157	2158	2159	2160	2161	2162	2163	2164	2165	2166	2167	2168	2169	2170	2171	2172	2173	2174	2175	2176	2177	2178	2179	2180	2181	2182	2183	2184	2185	2186	2187	2188	2189	2190	2191	2192	2193	2194	2195	2196	2197	2198	2199	2200	2201	2202	2203	2204	2205	2206	2207	2208	2209	2210	2211	2212	2213	2214	2215	2216	2217	2218	2219	2220	2221	2222	2223	2224	2225	2226	2227	2228	2229	2230	2231	2232	2233	2234	2235	2236	2237	2238	2239	2240	2241	2242	2243	2244	2245	2246	2247	2248	2249	2250	2251	2252	2253	2254	2255	2256	2257	2258	2259	2260	2261	2262	2263	2264	2265	2266	2267	2268	2269	2270	2271	2272	2273	2274	2275	2276	2277	2278	2279	2280	2281	2282	2283	2284	2285	2286	2287	2288	2289	2290	2291	2292	2293	2294	2295	2296	2297	2298	2299	2300	2301	2302	2303	2304	2305	2306	2307	2308	2309	2310	2311	2312	2313	2314	2315	2316	2317	2318	2319	2320	2321	2322	2323	2324	2325	2326	2327	2328	2329	2330	2331	2332	2333	2334	2335	2336	2337	2338	2339	2340	2341	2342	2343	2344	2345	2346	2347	2348	2349	2350	2351	2352	2353	2354	2355	2356	2357	2358	2359	2360	2361	2362	2363	2364	2365	2366	2367	2368	2369	2370	2371	2372	2373	2374	2375	2376	2377	2378	2379	2380	2381	2382	2383	2384	2385	2386	2387	2388	2389	2390	2391	2392	2393	2394	2395	2396	2397	2398	2399	2400	2401	2402	2403	2404	2405	2406	2407	2408	2409	2410	2411	2412	2413	2414	2415	2416	2417	2418	2419	2420	2421	2422	2
--	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	---

[illegible]

direction. An electric motor with a small cable could pull the array 14 against the spring bias in order to move the array over an document during the scanning operation.

The description and drawings from co-pending application 09/099,864 filed 6/18/01 are hereby incorporated herein by reference.

While the invention has been shown and described with respect to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and detail may be make without departing from the sprit and scope of the invention.

09930603-081904
FD3720" 00902660